IGBP-DIS

The Global 1 km AVHRR Data Set: Further Recommendations

Preliminary Report of Recommendations made by the IGBP-DIS Land Cover Working Group at its meeting held at the Department of Geography, University of Maryland, College Park MD., USA on 12th and 13th December 1991

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Attachment 4.8

Introduction:

Previous meetings of the IGBP-DIS Land Cover Working Group led to recommendations for the creation of a 1 km data set based on data from the Advanced Very High Resolution Radiometer (AVHRR). The report was discussed at a joint meeting of IGBP-DIS and several IGBP Core Groups at Toulouse in July 1992 and is being published as IGBP Report No. 20 (IGBP 1992).

Subsequently at a further meeting of the IGBP-DIS Land Cover Working Group held at the University of Maryland, College Park, in December 1991, the report's recommendations were discussed further and led to a number of refinements and modifications. The following report summarizes these changes. It needs to be stressed that these are largely technical changes and do not affect the original report's main recommendation that a 1 km data set be created.

Participants of the University of Maryland, December 1991 Meeting:

Members of the IGBP-DIS Land Cover Working Group

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Gilbert Saint (LERTS)
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Olivier Arino (ESA)
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1. Current status of 1 km data set creation.

A USGS-NASA memorandum of understanding with ESA has been prepared to assign responsibility for data collection through ground receiving stations for the globe. It also seems likely that CSIRO will become responsible regionally for some data acquisition.

NOAA is intending to schedule LAC data collection especially with respect to the problems of lack of coverage for Central America and Siberia. There is a reasonable likelihood that this procedure will be adequate for the former, but the frequency of coverage for the latter will be lower. It may be possible to reduce the area not covered by ground receiving stations, by taking advantage of the facilities operating in Mongolia. Dr Xu from the People's Republic of China also reported on the possibilities of collecting 1 km. data through their receiving station. Currently data are only archived at 5 km resolution.

It is recommended by the Working Group that plans for the international arrangements should be finalized as soon as possible and that the IGBP should be represented at any international meetings concerned with these arrangements.

Currently funds are available for data collection for 18 months from April 1992. It is the Working Group's understanding that funds have only be identified for the acquisition and archiving of the raw level 1 data stream for 18 months from April 1992. **It is strongly recommended that resources are identified as soon as possible to allow the processed data set, which is described below, to be generated in a timely fashion. It is recommended that the data set be available within 6 months of completion of the initial 18 months of data collection.**

2. Final definition of the 1 km product

The discussion of preprocessing methods benefitted substantially from inputs from the the O.S.S. Working group, several members of which were present at the Working Group Meeting (namely G. Saint (secretary), O. Arino, J. Eidenshink, B. Holben, P. Teillet, E. Vermote). In several of the pre-processing stages, procedures are not well established and it is anticipated that significant improvements will be possible in the future. As such it is likely that improved products will in all likelihood have to be created in future. Data should therefore be preserved in a form which readily permits such improvements to be made.

2.1 Calibration

The calibration coefficients for data collected by the AVHRR are clearly substantially different from the pre-flight ones, and it is recommended that the latter should not be used.

Acquisition of a global 1 km AVHRR data set is initially scheduled to extend from April 1992 to Sept. 1993. The data will be bridged by two satellites having temporally varying calibration coefficients. The Land Cover Working Group recognizes that to measure accurately geo- and biophysical properties of the earth, in-flight radiometric calibration must be used. We also recognize that in-flight calibration is not available for channels 1 and 2.

Calibration can be divided into two types, relative and absolute. The relative methods have proven from comparisons for the life spans of NOAA-7, -9 and -11 to agree to within 5% accuracy and have nearly identical trends. The absolute methods agree within 10% and often have different trends.

With the above record, **we recommend the IGBP 1 km product use the calibration coefficients provided by Holben et al. (1990) and Kaufman and Holben (1992) (the relative desert method) which will be continued through the 1993 acquisition period.** This method provides consistent and timely calibration coefficients.

We recommend the NOAA-11 acquisition be continued 3 months after the launch of NOAA-13 for the IGBP product. This will allow NOAA-13 to stabilize and allow sufficient time for in-flight calibration coefficients to be derived for the new instrument.

The Working Group endorses the concept of a tri-level electronic calibration bulletin board administered by NOAA/NESDIS as the owner of the AVHRRs. The top level should contain calibration coefficients recommended by

NOAA. IGBP recommends the anchored desert method as the only consistent published calibration record that is available on a timely basis for the top level. The second level includes all results from methods that have been peer reviewed and validated. The lower level could be for preliminary results not yet peer reviewed but it would allow timely, although potentially risky, access to calibration results. This method would also allow investigators in the field to easily compare their results and users early access to calibration coefficients. There remains a potential difficulty in the use of calibration coefficients, which stems from the requirement for some operational users to process data in real time and the fact that best estimates of the calibration coefficients will take some time to acquire.

The Working Group strongly recommends that NOAA take responsibility for the radiometric calibration of the AVHRR. An international community is involved in its calibration. We therefore recommend that the CEOS Cal/Val Working Group, which has an international base, take an active role by working with the NOAA/NESDIS calibration section and other investigators to calibrate, collate, evaluate and disseminate the calibration data. Ultimately, this includes seeking sponsorship for a routine calibration method, analysis and publication of the results and maintenance of the electronic bulletin board. **Whatever procedure is used there should be global application of coefficients.**

2.2 Atmospheric correction

2.2.1 Rayleigh scattering.

Correction of Rayleigh scattering should be performed with use of reference values as described in Teillet (1990). Correction for variations in atmospheric depth due to elevation should be corrected using a digital elevation model. For this purpose it is considered that ETOPO5 is sufficient.

2.2.2 Ozone correction

Consideration should be given to correcting for ozone using TOMS data rather than the ozone climatology originally proposed in IGBP Report No. 20. Benefits from using TOMS data will have to be assessed in relation to the efforts required in applying these data. If the TOMS data are not used, the climatology should be applied.

2.2.3 Water vapor correction

Following a very lengthy consideration of the various methods described in IGBP Report No. 20, it was finally concluded that none of the methods had sufficient reliability to be firmly recommended. **Consequently no correction for water vapor should be applied at this stage.**

It is recommended that the half degree water vapor estimates, made available by the NMC, should be distributed with the data set along with software to allow corrections to be applied; appropriate indications of the limitations of the approach should be included.

There is an urgent need for further research to develop and evaluate procedures of water vapor correction.

2.2.4 Aerosols

Once again a lengthy discussion resulted in the recommendation that **no correction should be applied for aerosols.** Several possible procedures were discussed, but each had sufficiently major limitations, that it was thought unwise to apply the procedures universally.

The urgent need for research to develop better procedures for aerosol correction was recognized by the working group.

2.2.5 Cloud screening/flagging

EDC currently carries out cloud identification using Channel 1 and Channel 2 values. **It is recommended that a thermal threshold using Channel 5 should be applied.**

The CLAVR cloud screening approach or some variant of it should be considered for improved cloud identification. Further research and evaluation is needed before this procedure can be definitely recommended.

It is recommended that whatever procedure is used there is no actual removal of data values. Instead the presence of cloud should be flagged, probably in a separate data plane.

2.3 Geometric correction

2.3.1 Geolocation of images

The importance of accurate geolocation was stressed by member of the working group. Apart from the need to establish the location of images in relation to ground observations, accurate geolocation and subsequent registration is essential to allow reliable monitoring. Taking account of what realistically can be achieved with the AVHRR system, **it is recommended that the 1 km product should have a root mean square error of 0.8 pixels in relation to known ground control points.**

Achieving high levels of registration accuracy is likely to require reliable topographic maps at scales as fine as 1:50 000 and that some human involvement in carrying out registration may well be required.

It is understood that a working group under CEOS will be carrying out a comparison of methods of geolocation. The IGBP-DIS Working Group welcomes this initiative and would like to receive a report of this work when it becomes available.

2.3.2 Resampling algorithm.

The main discussion revolved around the relative merits of nearest neighbor and cubic convolution resampling. The principal benefits of the former are preservation of radiometry and computational simplicity, but it suffers from an effective reduction in locational knowledge compared with cubic convolution.

Taking account of the various merits of the different procedures, **it is recommended that nearest neighbor algorithm is used. It is also recommended that in determining the value to be assigned to each location, the inverse method is used to avoid holes in the data field being created.** The inverse method means that, having defined the geometric projection to be used, one chooses the value in the

original image closest to that location, rather than starting with the original image and then calculating the new location of each of its pixel values in the new projection.

2.3.3 Choice of map projection

After a discussion of a wide range of alternative projections **it was decided to recommend the Goode projection**, which is an equal area projection. This projection also preserves, to a reasonable degree, the shape of the main continental land masses. Its main disadvantage is that there are major breaks in the oceans. **Software should also be included for the relatively simple transformation to Plat-Caree.**

2.4 Compositing procedures

2.4.1 Compositing period

Compositing periods must be consistent globally. **From the users point of view either a 9 or 10 day basic compositing period will be acceptable,** though once chosen the period should be consistent. On balance, the group preferred a 10 day compositing period . It will also be necessary to make whatever adjustments are necessary at the end of a year's compositing to ensure the same start day for the next year's data. A preference was expressed to ensure they each calendar year should start with a new composite on 1st January.

2.4.2 Compositing procedure.

The normal method of compositing is to select the highest value of the normalized difference vegetation index (NDVI) for each pixel for a given time period. The alternative approach of selecting the maximum simple difference between the red and near infrared bands is not recommended because it tends preferentially to select off-nadir pixels.

A variety of alternative compositing procedures were discussed including the use of thermal bands, because the maximum NDVI procedure is not satisfactory for the creation of composites of the individual visible and near infrared bands, leading to a spatially variable (speckled) appearance. Results from CCRS and NOAA indicate that other procedures can potentially yield better results though they have only been examined for relatively small test areas. Research in this area is urgently needed. **For the present it is recommended that the maximum NDVI procedure is used.**

2.4.3 Compositing of thermal data

Little work has been done on the optimization of procedures for the creation of thermal products. Research on this topic is essential for the creation of improved thermal data sets for channels 3,4 and 5. **It is recommended that the IGBP-DIS Working Group on Land Surface Temperature should urgently consider this issue.**

2.5 Archiving

In addition to the comments made in IGBP Report No. 20 on the subject of archiving, a number of additional points were made.

2.5.1 Data compression.

Given the very large volumes of data that will be created in the 1 km data set, greater consideration should be given to the use of lossless data compression methods.

2.5.2 Length of period of data collection.

Currently it is reported that funds have been identified by USGS-EDC and ESA-ESRIN to allow the archiving of data from April 1992 for a period of 18 months. **Given the importance of long term data collection, the Working Group strongly recommends the continued compilation of a global 1 km data for the foreseeable future in order to provide continuity with EOS-era instruments.**

2.5.3 Types of data to be archived.

In addition to the final product required by IGBP, it is essential that the basic daily 1 km data, which are collected, are also archived to allow the subsequent application of new pre-processing procedures. The complete global archive should be kept in at least one locality, and this data set should be available to users.

Standard formats agreed by CEOS should be used for all products. Software code to read these data in these formats or in any other format, which is used, should be provided with data products.

2.5.4 Methods of data distribution

It is recommended that the basic form of data distribution should be on CDs in keeping with the original proposal in IGBP Report No. 20. However in addition the possibility of electronic transfer should also be explored taking advantage of improved data transfer rates.

2.6 Required global 1 km product for IGBP's scientific objectives

A processed global data set should be created, archived and made available with a 1 km resolution and should contain the following bands, processed according to the procedures described above, with a temporal resolution of 9 or 10 days:

i) Band 1 (as a reflectance at 10 bit precision)
ii) Band 2 (as a reflectance at 10 bit precision)
iii) Band 3 (as a radiance at 10 bit precision)
iv) Band 4 (apparent brightness temperature at 10 bit precision)
v) Band 5 (apparent brightness temperature at 10 bit precision)
vi) The Normalized Difference Vegetation Index (at 10 bit precision)
vii) Solar zenith angle (8 bit precision)
viii) Satellite zenith angle (8 bit precision)
ix) Relative azimuth between sun and satellite (8 bit precision)
x) Day of pixel selected within compositing period (4 bits)
xi) Cloud mask (number of bits will be low, but will depend on procedure adopted).

Additionally auxiliary data must be included, for example in header files, giving information on dates of acquisition, satellite number, and references to algorithms which have been applied.

3. Liaison between IGBP-DIS and other agencies.

In order to ensure the creation of a 1 km data set which meets the scientific needs of the IGBP, it is essential that liaison be maintained with the various groups responsible for data

set collection and processing. One possible mechanism could be through the activities of CEOS and its various working groups. This should be facilitated by the attendance of IGBP at plenary meetings of CEOS.

It is also recommended that representatives from IGBP-DIS should be invited to the relevant CEOS Working Groups meetings and other relevant meetings between agencies and ground receiving station operators. The latter should include the meeting to be held at Pasadena on February 14th 1992. **In the opinion of the Working Group formal links between science groups such as IGBP and the various space and data processing agencies need to be established**

The report of this meeting should be communicated directly to CEOS, along with an expression of our concern that formal links between the Working Group and an appropriate working group or sub-committee of CEOS

It is recommended that any significant deviations in the nature of the 1 km data product generated by should be discussed with members of the IGBP-DIS Land Cover Working Group.

IGBP-DIS should continue to be involved in developing more detailed and specific recommendations concerning the contents of the data set, the media for its distribution, distribution mechanisms, user support and cataloguing.

References

Holben, B.N., Kaufman, Y.J. and Kendall, J. (1990) NOAA-11 AVHRR visible and near IR in-flight calibration. *International Journal of Remote Sensing*, 11(8), 1511-1519.

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Kaufman, Y.J. and Holben, B.N. (1992) Calibration of the the AVHRR visible and near IR bands by atmospheric scattering, ocean glint and desert reflection. *International Journal of Remote Sensing* (in press).

Teillet, P.N. (1990). *Report on a Special Meeting on AVHRR Data Preprocessing and Compositing Methods.* Canada Center for Remote Sensing, Ottawa, Ontario.